Estimating Indirect Costs of Injuries to Construction Workers

by

James R. Van de Voorde

Submitted in partial fulfillment of the requirements for the degree of

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SECTION 1: Introduction

The true costs of construction injuries consist of both direct costs, principally the worker's compensation claims, as well as indirect costs, which are less tangible but certainly real in terms of lost profits. For too long, the construction industry has largely viewed accidents as the cost of doing business. The true costs of accidents are often ignored by allocating worker compensation claims to company overhead costs and permitting job site indirect costs to be hidden in the direct labor and equipment costs codes for the project. By doing so, management is unable to identify, monitor and control these costs. A previous study sponsored by the Construction Industry Institute (CII), sought to estimate these indirect costs for both medical cases and restricted activity/lost time accidents. The evidence of nearly 600 cases revealed that indirect costs exceed the direct costs by factors of 4:1 for medical cases and 20:1 for lost time accidents when an appropriate allowance is included in the indirect costs for liability claims.

Managers of construction projects focus on the cost accounting reports generated by the project. However, if costs of worker injuries are not segregated within the report, management can not use their skills to control or "manage" those costs; and if these costs are not being managed, they are "eating up" profits. Perhaps the reluctance of isolating injury costs within a project cost account stems from the fact that gathering the actual costs associated with an injury is an administrative burden and takes a long time to accumulate (possibly years) because of the delayed nature of follow-up costs, medical bills and possible legal claims.

If contractors were able to estimate the indirect costs of a work related injury and to monitor these costs as they do for most major project cost items, they would quickly see the direct monetary effect these accidents have on project costs. Such a focus can only help in convincing contractors, as well as their foremen and superintendents, that accidents have significant costs and that a strong pro-active safety program will not only protect workers but increase the contractor's profit margin. Contractors manage project direct costs in great detail, yet they continue to ignore the true costs of accidents, allowing them to be hidden, resulting in greater lost profits.

The objective of this paper is to devise simple, reliable mathematical models which would enabie a contractor to estimate the indirect costs of a work-related injury in a timely fashion, namely on the very next day after the injury.

SECTION 2: Scenario

To illustrate how easily these indirect costs are "lost" in the cost accounting system and to show that these costs can be significant, a fictitious construction project will be described. This project consists of a school building on which approximately 75 workers are employed. Specific focus will be given to two particular incidents that occurred within a two week period. These events were injuries sustained by two different employees of a masonry subcontractor. One suffered a medical case injury and the other sustained a lost time injury.

These injuries occurred on the Middle School Addition. The medical case injury was sustained by Dave, an experienced journeyman bricklayer, who had been working on the project for about three weeks at the time of his accident. The accident happened early on Wednesday morning. Dave had begun work by cutting several bricks for the window ledger detail on the second floor. He considered himself as being an experienced bricklayer and more safety conscious that most. So while cutting the bricks, he properly wore his safety goggles which were always kept hanging on a post next to the saw. However, since he was the only one cutting the bricks on that day, he flipped the goggles up on top of his hard hat and climbed the ladder to hoist the bricks to the second floor. After a short while, the glasses became a nuisance and he took them off, hanging them on the hand rail. With one window ledger almost complete, he realized that he needed to cut two more bricks. He climbed down the scaffolding ladder to cut the last two units. It was not until he was at the saw, that he realized his safety goggles were still up on the scaffold rail. Well, for just two bricks, Dave figured that he would be okay without them. Unfortunately though, while cutting the second brick, some of the dust hit his right eye causing agonizing pain.

Immediately upon hearing the scream, his co-worker Juan rushed over to help. The masonry foreman, Paul, ran to bring the first aid kit which he kept in his pickup truck. The accident did not appear serious, although it was difficult for Dave to open his eye without a lot of pain. They flushed the eye with water and Paul, well aware that eye injuries are nothing to trifle with, directed Juan to take Dave to the emergency room of the local hospital to have the eye looked at and thoroughly cleaned.

It was about three hours later when Juan and Dave returned to the job site. Dave, wearing an eye patch, felt much better and more than a bit embarrassed about the whole thing. The doctor said he would be fine, that the eye suffered no permanent damage but that he needed to wear the patch to rest the eye muscles. Paul called Dave's wife and she came by the jobsite and took him home for some rest. Fortunately, the doctor said he would be able to be back at work the next day.

As the end of the work day approached, Paul wrote up his daily report for the general contractor. While writing, Paul kept thinking how lucky Dave had been. He hoped Dave would be back the next day and suffer no long term disability because of the injury. While tallying the time sheet, he noted that about 8 worker hours were lost that day because of the incident: a half hour for Juan and Dave to drive to and from the hospital (1 worker hour total), two hours each while waiting and/or receiving medical treatment (4 worker hours total) and another three hours lost sending Dave home early (3 worker hours total). Fortunately, the subcontractor was only slightly behind schedule and with some luck Paul hoped to catch up the next week. Paul then completed a brief safety incident report for the home office and decided that eye protection would be a timely topic for the next week's safety meeting.

On Thursday morning, Dave returned to work, as hoped for, without the eye patch. The crew was glad to see him so soon, and Dave was eager to get back to work. Dave felt good but he knew he was not functioning at quite 100% of his ability, especially since the injury caused frequent eye blinking. He was also more unsure of himself when climbing up and down the ladders. By Friday, Dave sensed no eye discomfort and felt that his production was back to normal. Dave did leave work early on Monday to visit his doctor for a follow-up check on his eye (3 worker hours). During that visit, his doctor pronounced him fully recovered.

It was hardly two weeks after Dave was hurt that Joe suffered a more serious injury. Joe, also a bricklayer, was working on the same wing addition on the second level. He had just returned from lunch on a Thursday, and had resumed his work duties. As he stepped near the end of the scaffold planking with several bricks in his hands, he lost his footing as the plank gave way. He fell to the ground directly onto a pile of stacked sprinkler piping. His apprentice, Sandra, ran over quickly to provide assistance. Joe grabbed his left side in pain and was bleeding from several minor cuts on his arms. Sandra called for the foreman to get some help. Paul was talking with the project superintendent at the time and was quickly summoned to the scene.

Joe's left side was very tender and with the possibility of internal injuries, Paul summoned an ambulance on his cellular telephone. Joe's left leg was also in pain. Everyone was trying to make Joe more comfortable while medical care was on the way. Both Paul and the superintendent asked how the accident happened. Joe told them how he fell, figuring that he did not have the planking overlapped properly and it pivoted as he stepped near the edge.

In a short while, the ambulance arrived and the emergency medical technician examined Joe's vital signs and apparent injuries. The hospital was called to expect their arrival and Joe was placed on a stretcher for transport. Paul directed Sandra to accompany Joe to the hospital while he remained behind to control the jobsite.

The superintendent was not pleased with the masonry subcontractor's recent safety performance, the second incident in as many weeks. To avert any other falls, Paul walked the entire area and personally checked the scaffolding. In all, he found several discrepancies: there were no end rails installed anywhere, several missing toe boards were noted and one ladder was in poor condition. As a result, Juan and Dave spent a half hour each making the necessary repairs.

Meanwhile, Joe received a thorough examination in the emergency room. It appeared that in addition to the minor cuts, he had three bruised ribs and a sprained ankle. Fortunately, Joe had worn his hard hat and incurred no head injuries. He was more comfortable once he realized that no serious injury had occurred. Of course, returning to work the next day was out of the question. Sandra took him home since he did not have to remain hospitalized overnight. According to the doctor, Joe would need bed rest for at least 6 days and at least two follow-up visits to check his progress as well as prescribe physical therapy. Sandra called Paul at the job site to let him know that Joe would be okay but would not be back to work until the middle of the following week.

Paul was relieved at the good news but still had to contend with the resulting problems at the jobsite. The superintendent was pressing him to finish the masonry work on the building by the end of following week so the earthwork subcontractor could be brought on site to excavate for and install the lawn sprinkler system. Landscaping could not begin until the sprinklers were installed. With one of his top bricklayers off work, Paul was concerned that he might not meet the deadline. On top of this, even the landscape subcontractor had given Paul a field memorandum requesting reimbursement for the piping broken by Joe's fall.

Paul was dismayed at the way work had come to a virtual halt on that Thursday. He estimated that he spent one full hour investigating the accident that day. He also directed the repair work, filled out the required OSHA and company safety reports and tried to rearrange the crew's work so that they still might be able to meet the general contractor's deadline. In addition, he was notified that the superintendent wanted to see him before he left the jobsite that afternoon.

The superintendent had called the school district's resident engineer, George, to report the accident and George told him that he wanted to meet with Paul on Friday. George wanted to discuss safety with Paul and make a jobsite safety inspection. The Superintendent was concerned about the masonry subcontractor's ability to finish up their portion of the work by the end of following week, and he was also concerned that any delay would upset the earthwork and landscaper's schedules as well as window installation. With good weather predicted only through the end of the week, he could not afford to lose a couple days on the schedule.

By the following Wednesday, Joe was back at work but his ribs were still tender. In fact, they were wrapped for protection and the constant bending slowed down his work. His ankle was fine now and everyone agreed that he was quite lucky. Unfortunately for his employer, the crew was not able to pick up the slack and it was evident that they would not complete the work until probably the following Tuesday, even if they did work all day Saturday. Joe also had to leave work early on both Thursday and Friday for physical therapy treatment (6 worker hours total). Paul relayed this to the superintendent, who after some heated discussion, agreed to hold off the earthwork subcontractor as well as the window installer. The crew did finish up the masonry work that Tuesday morning and proceeded to move the crew to the second classroom addition. On Wednesday morning, Joe returned to the doctor for a follow-up visit (3 worker hours) and was glad to hear that his ribs were healing well. The doctor suggested that he keep the wrapping on for another week and return for another check-up the following week. He also scheduled two more sessions of therapy that week (12 worker hours). At the second follow-up visit (3 worker hours), the doctor was satisfied with Joe's recovery and scheduled Joe's last two sessions of physical therapy for the next week (6 worker hours total).

These two fictitious incidents illustrate very real possible scenarios for "typical" medical case and lost time accidents. As these scenarios suggested, the foreman, Paul, recognized that valuable time was lost as a result of the injuries, but no actual assessment was made of the true costs associated with them. Like this masonry subcontractor, contractors need a tool to quickly and reasonably estimate the true costs of construction injuries in near real time.

The total true cost of an injury (TTC) equals:

TTC = Direct Costs + Indirect Costs (Including Claims)

Direct costs of injuries are available to contractors from their insurers. This paper will present two simple sets of models that contractors can use to estimate an injury's indirect costs, excluding claims. That is, the focus will be on the jobsite costs that are incurred at the time of the accident and for a short while thereafter. Claims costs vary significantly among companies, so firms might apply a factor based on their own claims experience. Insurers should be able to assist in this calculation. To develop these indirect cost models, a recent survey by the Construction Industry Institute (CII) was utilized to provide the necessary data.

SECTION 3: Background

The Safety Task Force of the Construction Industry Institute (CII) conducted a nationwide survey in 1990 to gather data on direct and indirect costs of construction work-related accidents. The objective of the study was to demonstrate the true value of the total costs of these accidents by determining the ratio of indirect costs to the direct costs. Direct costs of safety incidents are fairly well quantified by virtue of the workers compensation payments to injured workers. The study clearly demonstrated that these direct costs are only a small portion of the true total costs of accidents. Over 100 construction firms from 34 states contributed to the data base covering 185 different projects. A total of 573 cases out of the 794 responses received were complete enough to be analyzed for the study.

Each four page survey (Appendix A) gathered data on one safety incident. Injuries were classified either as medical case injuries, those requiring medical treatment but with the worker returning to work the next day, or as restricted activity/lost time incidents, those sufficiently serious to cause a temporary reassignment of duties or lost workdays.

The data on indirect costs entered on the survey were collected over time by each respondent and included some judgmental and projected cost estimates on lost productivity, etc. The direct cost data included was obtained by each respondent from their insurers. The results of the study produced the following cost ratios:

Table 1
COST RATIOS OF CONSTRUCTION WORKER INJURIES

Cost Ratio	Medical Case Injuries	Restricted Activity/ Lost Time Injuries
Average of All Cost Ratios (Indirect to Direct) (Claims Excluded)	1.62	1.79
Average of All Cost Ratios (Indirect to Direct) (Claims Included)	4.2	20.3

As evident, the study showed that the indirect costs of accidents significantly exceed the direct costs. The CII study also conducted further analysis of the cost data regarding this ratio for various labor trades, project types, project sizes and contract types.

SECTION 4: Research Methodology

The impetus of this researcher's effort is to focus on the dollar value of the indirect costs of injury accidents. This permitted the use of some survey data disregarded by the CII study because of missing direct costs and additional surveys received by the Task Force after the CII study was completed. A total of 834 cases were analyzed for the current study. Of these, 565 were medical case injuries and 269 were restricted activity/lost time injuries. To simplify the latter type injury, the term lost time case will be used during the rest of this paper. The direct cost data of these cases were not a primary interest for this study and were not utilized. Also, all current data analysis and results do not include any costs for claim settlements. The distribution of the indirect cost data is shown in the histograms in Appendix B.

Analysis of the data was performed using the computer program, "Statistical Package for the Social Sciences" or SPSS which is the same one utilized for the CII Safety Task Force study. The program generated standard statistics for the data variables such as means, medians, standard deviations and variances. Several data classifications were used such as incident type (medical case or lost time injury), and the various categories of component costs making up the indirect costs. The definition file, which includes all the formulae used, is in Appendix C.

The significance of the correlation between variables was analyzed using the non-parametric method of Pearson's Correlation Coefficient. This measures the direction as well as extent of relationship between two variables. Therefore this type of analysis could check not only if an independent variable had a linear relationship to the dependent variable (injury frequency rate) but also if the injury rate decreased or increased based on the independent variable. Further analysis was conducted using multiple linear regression analysis to evaluate the relationship between the principle dependant variable of interest, indirect costs, and several independent variables gathered from the survey. Based on the analysis, two simple mathematical models were devised to estimate the total indirect costs of injuries, one for medical cases, the other for lost time cases. These cost totals calculated by the models reflect the total mean indirect costs derived from the survey responses. Additional analysis was conducted to make use of this larger pool of data (834 versus 573 cases) in order to validate the earlier study's results concerning some of the other indirect cost comparisons for project size, project type, contract type and labor arrangement (union or merit/open shop).

SECTION 5: Results

PART A

Overall Characterization of the Data

This section will present the results of this study and discuss the significance of the findings. Prior to this presentation, however, it may be helpful to briefly define and describe the pertinent variables analyzed. The principle variable of interest is the total indirect cost of an injury accident, without any allowance for liability claims costs. This variable, indirect cost, represents the summation of several categories of costs and within each category are one to five component costs which represent a specific response to a question on the survey.

There are six cost categories:

Supervisory and Administrative Costs

This category includes the following component costs:

•staff time spent assisting the injured worker
•staff time investigating the accident
•preparation of injury reports
•time spent with project owner or media regarding the accident
•time spent with any regulatory inspectors following the accident

Impact Costs

These costs were calculated rather than drawn from the survey data. The method used was identical to the CII study. Also known as ripple effects, these costs were recognized as difficult to identify and quantify. Under this category were included costs for: lost productivity for visits by home office personnel, costs associated with long distance telephone calls, additional work for payroll personnel, consumption of administrative and first aid supplies, etc. The CII study conservatively estimated these costs to be 20% of the total indirect costs associated with each injury based on predicted costs of several industry experts.

Injured Worker Costs

This category includes all indirect costs directly associated with the injured worker:

- lost productivity of the worker on the day of the injury
- lost productivity of the worker due to receiving follow-up treatment
- lost productivity of the worker after resuming work
- cost to transport the injured worker from the jobsite to the treatment facility

Crew Costs

This cost category includes the indirect costs associated with the impact of the injured worker on the productivity of the worker's crew. Component costs are:

- time lost by the crew or a crew member assisting the worker
- crew time required to complete additional work necessitated by the accident
- lost crew productivity due to the accident
- lost crew productivity due to any regulatory visit or inspection
- lost crew time due to watching the events and discussing the accident

Material and Equipment Damage Costs

These costs consist of two component costs:

- costs of any additional productivity lost due to the damage to equipment or materials
- costs to directly repair or replace the damaged material or equipment

This latter cost was based on not the survey data but, as was done in the CII study, on an estimate by the Task Force. The CII study referenced a previous study covering over 11,000 construction-related injuries (Brown, 1988) . It determined that the average cost for this item was $100. This current study used this figure for both the medical cases injuries and the lost time cases.

Replacement Worker Costs

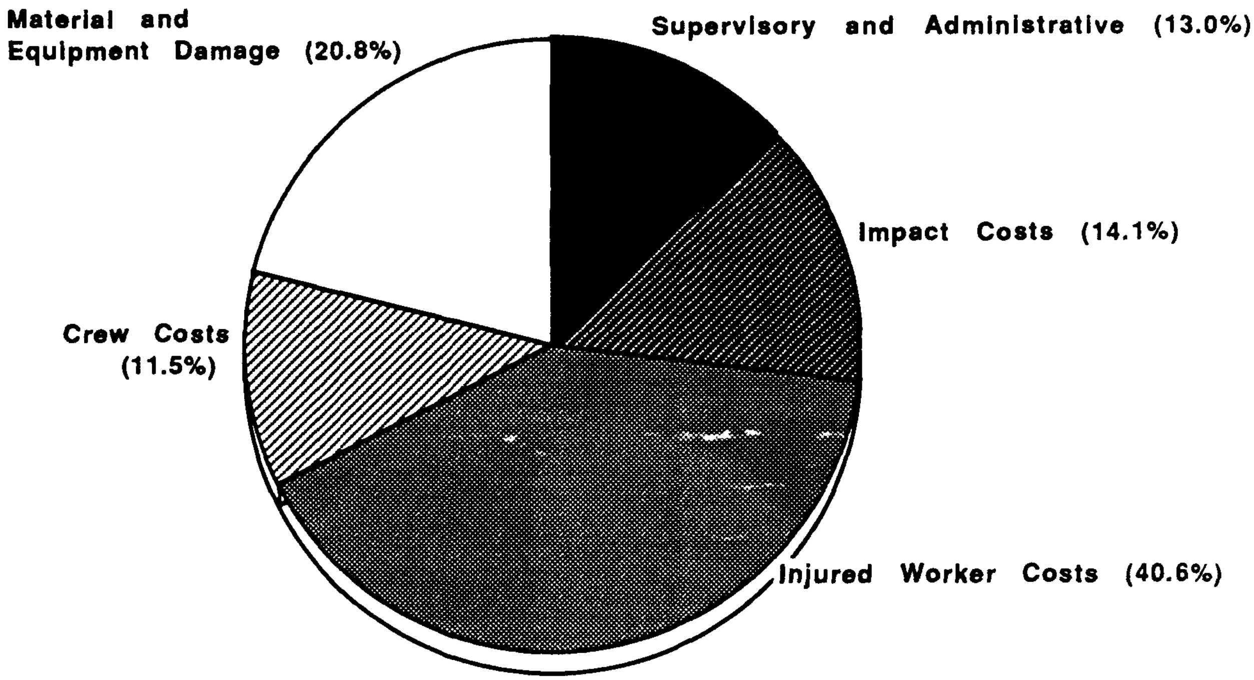
This category included two component costs:

- •costs associated with training or instructing a replacement worker
- •reduced productivity of the replacement worker compared to the injured worker prior to the accident

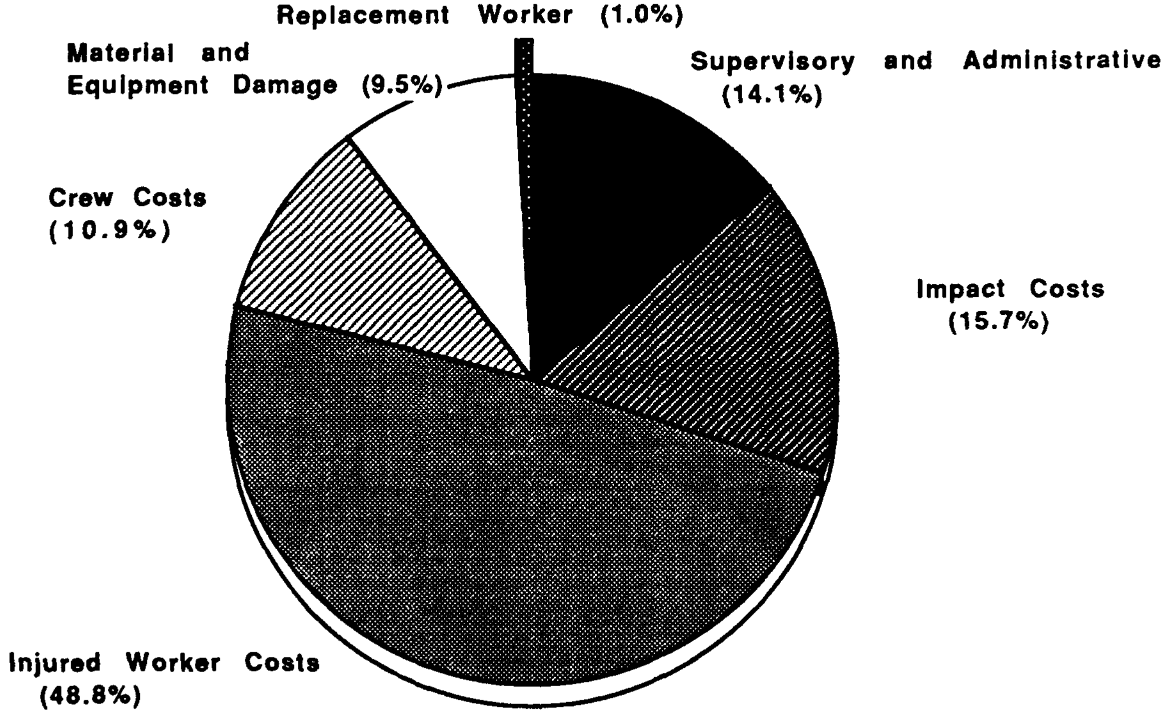
The average indirect costs along with a breakdown of the cost categories by component costs are shown in Table 2. These cost exclude any claims costs. The average indirect cost for a medical case injury was $526 and the indirect cost of a lost time injury was $1810. These costs (based on 834 injury cases) slightly exceed the indirect costs calculated in the CII study: $442 for a medical case injury and $1613 for a lost time injury. However, the differences were not statistically significant at the 5% level ($p < .05$). The CII study was based on 574 total injury cases. Figure 1 graphically depicts the same indirect cost category breakdowns listed in Table 2.

Table 2
INDIRECT COSTS OF CONSTRUCTION INJURIES

Cost Category Component Cost	Average Indirect Cost per Injury Based on 834 Cases			
	Medical Cases		Lost Time Cases	
	Component Costs	Subtotal	Component Costs	Subtotal
Injured Worker Costs				
Lost Productivity on Day of Injury	$43.70		$77.21	
Lost Productivity Due to Follow-up Treatment	$98.56		$598.26	
Lost Productivity After Resuming Work	$48.92		$170.93	
Cost of Transporting Injured Worker	$22.20		$38.86	
		$213.38		$885.26
Crew Costs				
Assisting Injured Worker	$20.51		$42.78	
Completing Additional Work Due to Accident	$2.22		$5.19	
Lost Productivity Due to Accident	$29.94		$112.46	
Lost Productivity Due to Inspection	$0.06		$4.45	
Lost Productivity Due to Watching Accident	$7.64		$32.91	
		$60.37		$197.79
Replacement Worker Costs				
Reduced Productivity of Replacement Worker	$0.61		$1.48	
Training the Replacement Worker	$0.65		$15.02	
		$1.26		$16.50
Supervisory/Administrative				
Staff Time Assisting Injured Worker	$21.94		$53.74	
Investigating the Accident	$24.76		$148.01	
Preparing Reports	$18.71		$43.69	
Time with Media or Project Owner	$2.80		$9.17	
		$68.21		$254.61
Damaged Property				
Repairing Damage	$9.25		$71.27	
Material Damage	$100		$100.00	
		$109.25		$171.27
Impact Costs		$73.58		$285.08
Total Indirect Costs		**$526.05**		**$1810.51**



Medical Case Injuries



Lost Workday Cases

Figure 1
Indirect Component Costs

PART B

Estimating Indirect Costs Using Mathematical Models

The above values for average indirect costs may be used by contractors or industry p\ ~sonnel to approximate the indirect costs of injuries. However, by using multiple linear regression analysis, simple mathematical models can be developed to more accurately predict the indirect cost of a specific injury accident. Again, these costs do not include any liability claims costs and reflect only the indirect jobsite costs near the time of the injury incident. Multiple linear regression analysis was utilized to identify the strongest variables which influence the indirect costs of both medical case and lost time injuries.

For medical case injuries, the following variables were identified by the analysis to be indicators of the total dollar amount of an injury's indirect costs:

- •Costs associated with lost productivity due to the injured worker seeking follow-up care and treatment
- •Costs associated with the lost time of the injured worker on the day of the injury
- •Costs of the staff personnel assisting the injured worker on the day of the injury

For lost time injury cases, the following variables were identified:

- •Costs associated with lost productivity due to the injured worker seeking follow-up care and treatment

- Costs associated with the lost time of the injured worker on the day of the injury
- Costs of the staff personnel investigating the accident

For both types of injuries, the "follow-up" type costs were the strongest influencing factor on the total indirect costs. The proposed cost estimating models would then be based on the above variables. However, timeliness is vital in cost accounting for project management actions to be effective. The cost associated with lost productivity due to follow-up treatment, by their very nature, are not often known until several weeks, or even months, after the injury has occurred. Yet, since this variable is the best single indicator of total indirect costs, a two step modelling process is proposed.

A **Quick Model**, based on the costs associated with work time lost on the day of the injury (for both cases) and on the costs of staff personnel assisting the injured worker (for medical cases) and costs of staff investigating the accident (for lost time cases) can be developed to permit a contractor to readily estimate the approximate total indirect costs of either a medical case or lost time injury on the very next day after the injury. Then, in the second step, after follow-up costs (in terms of worker hourly wage and number of lost work hours) are known, a more accurate total of indirect costs can be estimated by a **Follow-Up Model**. Then the cost accounting figures can be revised accordingly.

Medical Case Injuries: Quick Model

Total Indirect Cost = \$150 + \$79(H + A)

where: H is the number of hours lost on the day of the accident

and A is the number of hours spent by the staff assisting the worker on the day of the injury

The above model is based on the average total indirect costs of \$526 and average values for the variables H and A of: 3.23 hours and 1.54 hours respectively. The R Square coefficient from the regression analysis was 37.2%.

Medical Case Injuries: Follow-Up Model

Total Indirect Cost = \$150 + \$15(F) + \$30(H) + \$100(A)

where: F is the number of hours lost by the injured worker due to follow-up care,

H is the number of hours lost on the day of the accident,

and A is the number of hours spent by the staff assisting the worker on the day of the injury

The above model is also based on the average total indirect costs of \$526 and average values for the variables F, H and A: 8.34 hours, 3.23 hours and 1.54 hours respectively. The R Square coefficient from the regression analysis was 79.3%.

Lost Time Case Injuries: Quick Model

Total Indirect Cost = \$625 + \$102(H + I)

where H is the number of hours lost on the day of the accident

and I is the number of hours spent by the staff investigating the accident

The above model is based on the average total indirect costs of \$1810 and average values for the variables H and I of: 5.00 hours and 6.62 hours respectively. The R Square coefficient from the regression analysis was 42.6%.

Lost Time Case Injuries: Follow-Up Model

Total Indirect Cost = \$625 + \$20(F + H) + \$50(I)

where: F is the number of hours lost by the injured worker due to follow-up care,

H is the number of hours lost on the day of the accident,

and I is the number of hours spent by the staff investigating the accident

The above model is also based on the average total indirect costs of \$1810 and average values for the variables F, H and I: 37.4 hours, 5.00 hours and 6.62 hours respectively. The R Square coefficient from the regression analysis was 81.2%.

The validity of these models for union and open shop contractors is analyzed and presented in Appendix D. Likewise, the application of these models for lump sum and cost plus contracts is presented in Appendix E. The analysis presented in these appendices concludes that the models previously developed are reasonably accurate for both union and open shop contractors and for both lump sum and cost plus contracts.

With these models, the total indirect costs (excluding claims) can easily be estimated shortly after the accident. Contractors can increase these costs to reflect their company's historical claims experience to more accurately estimate the true indirect costs of accidents. With the addition of direct costs of the accident, provided by the contractor's insurer, management has available a reasonable estimate of the total true costs (TTC) of a particular accident. Appendix F shows how the number of variables for each model was selected.

PART C

Additional Results

Further analysis was conducted to validate the CII study results as well as review indirect costs as a function of labor source, e.g. union or merit/open shop. The projects included in the survey ranged in size from under $1 million to approximately $500 million. The projects were broken down into four size classifications in the CII study

- Less Than $2,000,000
- $2,000,000 to $10,000,000
- $10,000,000 to $75,000,000
- Over $75,000,000

. This research evaluated the total indirect costs for these four size classifications. The results are depicted in Figure 2. Concurring with similar analysis of the CII study, indirect costs increase with project size. As larger projects have significantly more employees, more layers of jobsite management and staff and more complexity involving interdependence of schedules and subcontractors, it is not unreasonable to expect the larger projects to experience higher indirect costs.

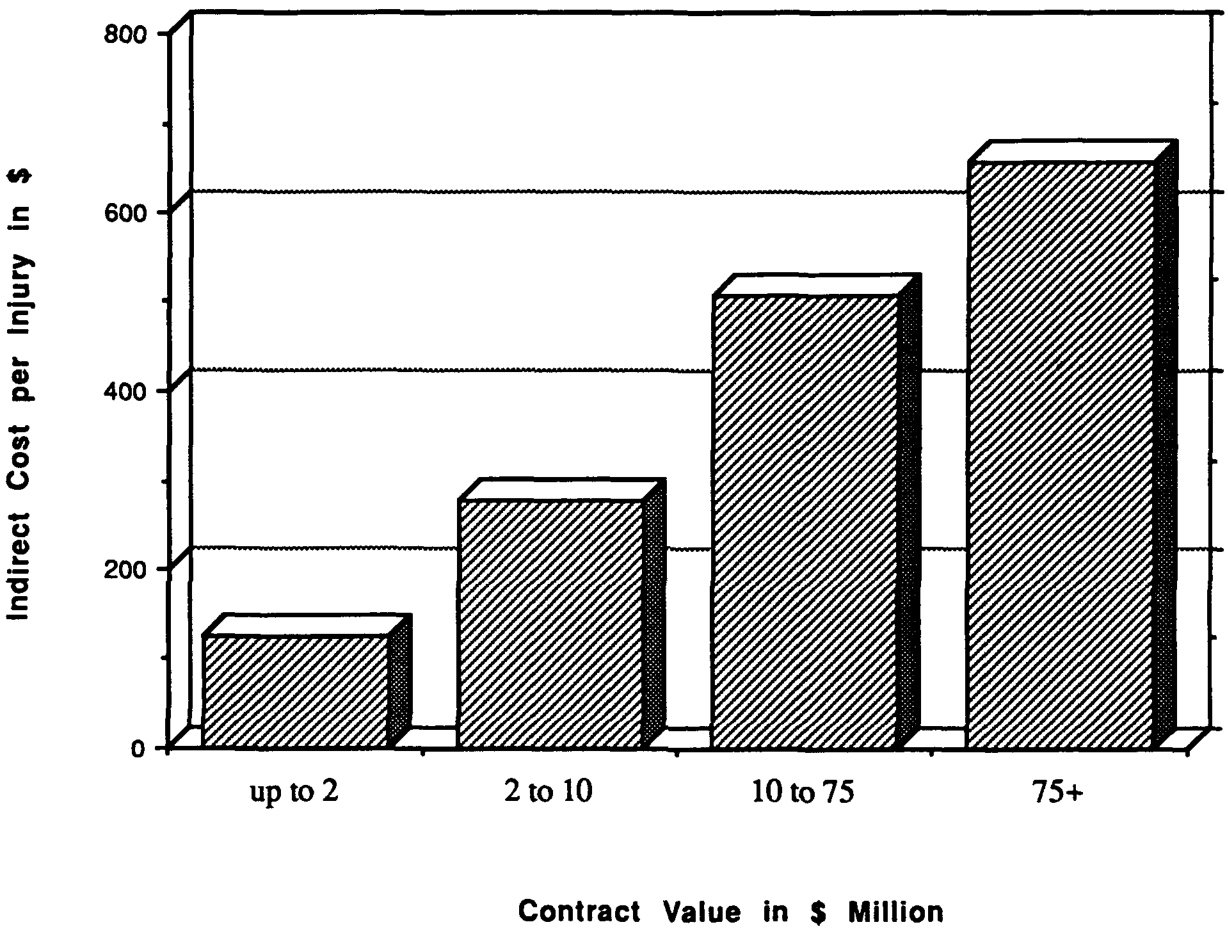


Figure 2
Contract Value and Indirect Costs

An analysis of indirect costs based on the project type was also conducted. The results are shown below:

Table 3
INDIRECT COSTS BY PROJECT TYPE

Project Type	Average Indirect Costs	
	Medical Case Injuries	Lost Time Injuries
New Grassroots Construction	$580 (63) *	$1343 (47) *
New Construction at Existing Facility	$488 (313)	$1992 (127)
Maintenance Work	$686 (68)	$2875 (26)

* values in parentheses represent the number of injury cases

The results indicate that for both medical and lost time cases, <u>maintenance type contracts tend to have higher indirect costs compared to new construction</u>, either a new construction project or a new project at an existing facility. It should be noted however, that the sample size for lost time injuries for maintenance type work was twenty-six. The maintenance costs were considerably influenced by 3 of the 26 cases which had indirect costs over $10,000. The median indirect cost for the lost time injuries was $935, compared to a median value of $700 for new construction work (both types of new construction projects combined). The difference between the indirect costs of both types of injuries were not statistically significant at the $p < .05$ level. Further analysis was conducted by breaking down the average indirect cost totals into their respective Cost Categories (see description of categories on page 15) to determine where this cost difference arose. Of the six cost categories making up the indirect costs, the Injured Worker costs were higher for the maintenance work injuries compared to new construction work ($1165 compared to $854). Also the Supervisory/Administrative costs of the maintenance contract lost time injuries were over double the new construction indirect costs ($561 compared to $264). There was not virtually no difference in the costs category of the Injured Worker's Crew.

Table 4 shows the results of comparing indirect costs for the type of contract involved. As concluded by the CII study, cost plus contracts have higher indirect costs compared to lump sum or unit price contracts. These results were statistically significant at the 5% level for the Medical Case Injuries and at the $p < .10$ level for the Lost Time Injuries. Again, these costs were broken down by Indirect Cost Categories for the Lost Time cases for further analysis. The indirect costs associated with Injured Worker's Crews were slightly higher for the cost plus contracts compared to the Lump sum contracts ($291 compared to $191). Injuries on cost plus projects tended to have double, on the average, indirect costs associated with the Injured Worker cost category ($1095 compared to $508), ($p < .01$). The median values of this cost category reflect similar difference. For the cost plus contracts, the median values of the Injured Worker cost was $439 while the median for the lump sum similar costs was $101. This is difficult to explain from a safety standpoint. It may be more reflective of the nature of cost accounting and reporting on cost plus contracts compared to fixed price or lump sum cost reporting, even when the information is simply recorded on a survey. Somewhat surprising, the Supervisory and Administrative costs were higher on lump sum contracts than the cost plus contracts ($357 compared to

$173), although not nearly enough to offset the Injured Worker costs. The most significant factor in this was the amount of time spent investigating the accident, which on the average was four times higher on lump sum contracts compared to the cost plus contracts ($238 compared to $55). This could be a realization on the contractor's part that injuries cut into profits and proper investigation into a past accident may help prevent future ones.

Table 4
INDIRECT COSTS BY CONTRACT TYPE

Contract Type	Average Indirect Costs	
	Medical Case Injuries	Lost Time Injuries
Lump Sum/ Unit Price	$439 (325) *	$1545 (123) *
Cost Plus	$627 (173)	$2053 (91)

* values in parentheses represent the number of injury cases

The last data analysis involved a comparison of the indirect costs for union and merit/open shop employers. The CII study revealed "no statistically significant difference between the means of the ratios of indirect to direct costs of the merit shop and union shop projects." The CII study also reported that the indirect costs appear slightly higher on union shop projects but not appreciably so. This research analyzed the indirect component costs for medical and lost time injuries for both merit/open shop and union shop contractors. The results are shown in Table 5:

Table 5
Indirect Cost of Injuries and Labor Source Measured in Dollars

Cost Category Component Cost	Open/Merit Shop Based on 425 Medical Cases	Open/Merit Shop Based on 156 Lost Time Cases	Union Shop Based on 140 Medical Cases	Union Shop Based on 87 Lost Time Cases
Injured Worker Costs				
Lost Productivity on Day of Injury	$ 35.41	$ 73.60	$ 68.52	$ 85.78
Lost Productivity Due to Follow-up Treatment	$ 62.63	$341.09	$ 80.47	$1070.60
Lost Productivity After Resuming Work	$ 59.22	$231.61	$ 20.70	$ 51.77
Cost of Transporting Injured Worker	$ 19.26	$ 40.22	$ 33.53	$ 33.60
Crew Costs				
Assisting Injured Worker	$ 20.13	$ 51.41	$ 23.15	$ 28.11
Completing Additional Work Due to Accident	$ 3.04	$ 7.19	$ 0.00	$ 1.86
Lost Productivity Due to Accident	$ 21.33	$153.28	$ 57.10	$ 38.51
Lost Productivity Due to Inspection	$ 0.09	$ 1.67	$ 0.00	$ 0.46
Lost Productivity Due to Watching Accident	$ 6.49	$ 44.29	$ 11.63	$ 12.85
Replacement Worker Costs				
Reduced Productivity of Replacement Worker	$ 0.22	$ 2.34	$ 1.86	$ 0.00
Training the Replacement Worker	$ 0.87	$ 19.44	$ 0.07	$ 4.34
Supervisory/Administrative				
Staff Time Assisting Injured Worker	$ 21.00	$ 69.62	$ 26.61	$ 21.70
Investigating the Accident	$ 27.25	$170.15	$ 19.61	$ 112.81
Preparing Reports	$ 19.66	$ 47.24	$ 16.99	$ 39.02
Time with Media or Project Owner	$ 3.37	$ 12.40	$ 1.44	$ 2.64
Damaged Property				
Repairing Damage	$ 12.65	$107.42	$ 0.06	$ 8.91
Impact Costs (20% of above)	$ 62.51	$274.57	$ 72.31	$ 302.59
Material Damage ($100)	$ 100	$ 100	$ 100	$ 100
Total Indirect Costs	$ 475	$1747	$ 534	$1915

The overall indirect costs were not statistically different for either the Medical Case or Lost Time Injuries ($p >> .05$). Examining the specific component costs yields no consistent trends in the data. Injured worker costs were higher for lost time accidents under the union shop ($1070 compared to $341) while the costs associated with lost crew productivity due to the accident were higher for the open shop employers compared to the union shop employers ($153 compared to $38). In order to eliminate any bias of the results shown in Table 5 because of wage scale differences between the two shops, the analysis was repeated using worker hours from the survey instead of dollar costs. These results are shown in Table 6. The average total number of worker hours lost were higher for the open shop cases for both types of injuries. The values highlighted in bold print account for most of the hourly total differences. All highlighted sets of data were then examined for the median value of the survey responses to see if a few extreme responses affected the mean values. The only differences in median values were for the lost time injuries for the two Injured Worker component costs. Overall, therefore this analysis confirms the CII study conclusions that <u>there is no statistically significant difference in total indirect costs of injuries</u>.

Table 6
Indirect Costs of Injuries and Labor Source Measured in Worker Hours

Cost Category	Open/Merit Shop Based on		Union Shop Based on	
Component Cost	425 Medical Cases	156 Lost Time Cases	140 Medical Cases	87 Lost Time Cases
Injured Worker Costs				
Lost Productivity on Day of Injury	2.70	5.50	3.35	4.32
Lost Productivity Due to Follow-up Treatment	6.87	**25.75** (5)	3.43	**58.72** (0)
Lost Productivity After Resuming Work	**11.30** (0)	**41.57** (8)	**4.22** (0)	**18.86** (0)
Crew Costs				
Assisting Injured Worker	1.41	3.53	2.56	1.44
Completing Additional Work Due to Accident	0.62	1.66	0.00	0.09
Lost Productivity Due to Accident	**7.78** (0)	**27.88** (0)	**1.52** (0)	**2.32** (0)
Lost Productivity Due to Inspection	0.01	0.13	0.00	0.02
Lost Productivity Due to Watching Accident	0.36	1.90	0.74	0.56
Replacement Worker Costs				
Reduced Productivity of Replacement Worker	0.27	5.79	0.29	2.39
Training the Replacement Worker	0.10	1.44	0.01	0.35
Supervisory/Administrative				
Staff Time Assisting Injured Worker	1.53	3.63	1.70	1.29
Investigating the Accident	1.93	7.46	1.16	5.41
Preparing Reports	1.27	2.70	1.26	2.88
Time with Media or Project Owner	0.18	0.57	0.07	0.09
Damaged Property				
Repairing Damage	0.77	4.85	0.04	0.25
Total Indirect Worker Hours	37	134	20	99

Note: The values in parentheses are median values for the bold print figures immediately above the medians.

PART D
Applying the Cost Models to the Scenarios

The injury cost models can be used by a contractor to estimate the indirect costs of accidents. As an illustration, these models will be applied to the two previously described injury scenarios at the Middle School Addition project.

Once Dave returned to work on the day following the injury, the injury could be classified as a medical case injury (no lost time). The subcontractor could then use the Quick Cost Model to estimate the indirect costs of the injury as follows: *Total Indirect Costs = $150 + $79 times the sum of the hours missed by the injured worker (Dave) on the day of the injury and the hours spent by the staff, in this case Paul, assisting Dave.* Dave missed a total of 5.5 hours on the day of the accident and Paul spent 1 hour assisting Dave. This model estimates $664 for the indirect costs [$150 + $79(5.5 + 1)]. The subcontractor's project manager would then "charge" this amount (or increase it by a factor to account for potential liability claims costs) against a "Worker Injury" cost item in the project budget. To keep the accounts balanced, an equal amount would then be subtracted from the "Jobsite Overhead Expense" or "Contingency" account. This is the most direct, and appropriate, manner to demonstrate how the costs of jobsite injuries actually add to the subcontractor's expenses and reduce the project's potential profits. This accounting entry would be shown in the next monthly project status report.

It should be recognized that the allocation of dollars spent on the indirect costs of injuries is merely an accounting function and does not reflect actual cash flow. For example, the hours lost by Dave could probably have been charged to the masonry window sills account or some other generic labor cost code. While these accounts are not addressed by the procedure outlined above, the important point is that the allocation of costs of injuries is designed to focus attention on the fact that injuries are costly. The procedure, as outlined, is a simple, albeit not extremely accurate, accounting method.

After Dave's follow-up visit the week after the injury, he was diagnosed as fully recovered. Since no additional follow-up treatment was required, the Final Cost Model could be used to more accurately estimate the indirect costs of his injury. Using this model where *Total Indirect Costs = $150 + $15 times the hours spent on follow-up care + $30 times hours lost and $100 times hours spent by the staff, in this case, Paul, assisting Dave.* In total, 3 hours were spent on follow up care by Dave. This model estimates a new total of $460 for indirect costs, [$150 + ($15 X 3) +($30 X 5.5) + ($100 X 1)]. The costs are lower because of the fewer hours (less than the average of 8.34) spent on follow-up care. If this model were to be utilized, the accounting entries would be revised on the next status report. The subcontractor could have simply waited until the follow-up was complete and used the Final Cost Model if project costs did not need to be submitted for a status report or if immediate accounting adjustments were not considered important.

The second injury, involving Joe, was obviously a lost time case since he did not return to work the Friday, the day after his injury. The subcontractor could then use the Quick Cost Model to estimate the indirect cost of this accident: *Total Indirect Cost = $625 + $102 times the sum of hours missed on the day of the injury and the hours spent by the staff, in this case Paul, investigating the accident.* Four hours were missed by Joe on the day and Paul spent one hour investigating the accident. This results in a total of $1135 for the indirect costs caused by this incident, [$625 + ($102 X (4 + 1))]. Again, this cost would be added to the previous $460 from Dave's injury for the "worker Injury" cost item in the project's budget and $1135 subtracted from "Jobsite Overhead Expenses" or "Contingency" account. A few weeks later, once Joe has fully recovered from his injury, the project manager could use the Final Cost Model to revise the $1135 estimate. *Total Indirect Costs = $625 + $20 times the sum of hours lost to follow-up care and hours lost by Joe on the day of the injury + $50 times the hours spent by Paul investigating the accident.* This revised total is $1355, [$625 + ($20 X (30 + 4)) + ($50 X 1)]. The accounting figures could then be revised for the next status report.

As a result of these two accidents, the total indirect costs equal $1815 ($460 + $1355). To "pay" for these costs, the project's jobsite overhead available for other items was reduced by an equal amount, $1815. For this subcontractor, such an expense is no longer hidden in the labor cost item, where previously the time lost by Dave and Joe, because of the injury and follow-up care, etc. would just have been coded as labor expenses. Management now can clearly see the fiscal impact these accidents have on the project budget.

SECTION 6: Summary and Recommendations

This study conducted further data analysis of an earlier CII study concerning the indirect costs of jobsite accidents on construction projects. Average indirect costs were examined from over 800 cases obtained in the CII study. As done in the CII study, the analysis segregated medical case injuries from lost time/restricted activity cases. Two realistic scenarios were developed to illustrate how these indirect costs arise for both medical case and lost time injuries.

Based on the CII data, two sets of mathematical models were proposed to enable contractors to estimate the dollar value of the indirect costs associated with a particular accident within days of the injury. A second, more accurate, set of cost models were proposed to estimate these indirect costs after certain follow-up data had become available. Additional analysis of the CII data concurred with four of the CII study's observations:

- as a project's value increases, so do the indirect costs of accidents
- injuries on maintenance contracts have higher indirect costs than do injuries on "new construction" type projects
- injuries on cost plus contracts have higher indirect costs than do injuries on lump sum or unit price contracts
- there was no significance difference in indirect costs for injuries on union shop or merit/open shop projects

As long as contractors mismanage their indirect as well as direct costs of safety injuries by allowing them to get lost in the overhead or labor cost codes, managers will not see the true cost of injuries. Management attention can best be achieved by first estimating the indirect costs associated with injuries by using simple models, such as those proposed in this paper or as specifically developed to reflect the experience of the company. These costs can be estimated shortly after an accident and they can be charged directly to a specific "Costs of Injuries" cost code for the project. Likewise to keep the cost accounts balanced, an equal dollar amount would be subtracted from perhaps "Jobsite Overhead Expenses" account. Such a procedure would enlighten the entire project team to the fiscal impact of these accidents, "driving home" the truth that good jobsite safety not only save lives and limbs but saves money as well.

BIBLIOGRAPHY

Construction Industry Institute, Safety Task Force, "Indirect Cost of Construction Accidents", (to be published), University of Texas, Austin, 1991.

APPENDIX A

CONSTRUCTION INDUSTRY INSTITUTE
Safety Task Force

Study of Insured and Uninsured Costs
of Jobsite Accidents in the Construction Industry
(Please print all entries)

(1) COMPANY NAME ______________________________

(2) Project Location- City & State ______________________________

(3) Report No ______________

INFORMATION ABOUT THE INJURED WORKER

(4) Name of Injured ______________________ (5) SSN ______/______/______

(6) Date of Injury ______/______/______
mm dd yy

(7) Craft/occupation (Please check)

(a) Boilermaker ____

(b) Brickmason/stonemason ____

(c) Carpenter ____

(d) Carpet installer ____

(e) Cement/concrete finisher ____

(f) Crane operator ____

(g) Electric power installers/ repairers ____

(h) Electrician ____

(i) Excavating and loading machine operator ____

(j) Grader, dozer & scraper operator ____

(k) Insulation worker ____

(l) Laborer ____

(m) Mechanic/repairer ____

(n) Painter ____

(o) Plasterer ____

(p) Plumber/pipefitter ____

(q) Roofer/slater ____

(r) Sheetmetal worker ____

(s) Structural metal worker ____

(t) Supervisor/Foreman ____

(u) Truck Driver ____

(v) Welder ____

(w) Other, please specify ______________

(8) Nature of Incident (check only one)

(a) medical/doctor case____
(b) restricted activity/lost workday case____

(9)Job Relatedness of Injury (check only one)

(a) Injury is clearly related to work activities ____
(b) Injury not verified as being work related, but worker claims it is ____
(c) Injury is not work related, but is covered by worker's compensation ____

(10) Hourly wage of injured worker excluding fringes $__________

(11) Number of productive hours lost by injured on the day of injury __________ hours

(12) Number of productive hours lost by injured due to follow-up medical treatment ________ hours

(13) Assuming the injured worker's productivity was 100% before the injury, was it 100% after returning to work?

(a) yes___
(b) no, it was only ________%

(14) How many hours did the injured worker work at this reduced level of productivity?________ hours

COST OF OTHER CRAFT WORKER'S TIME DUE TO WORKER'S INJURY

(For all wage information give base hourly wage which excludes fringes)

(15) Number of hours fellow workers spent assisting the injured worker in obtaining medical treatment (include time getting first aid, transportation, accompaniment to treatment facility, etc.) __________ hours

(16) Average hourly wage of these assisting workers $____________/hour

(17) Estimated cost of transporting injured worker (exclude labor costs) $____________

(18) Were any other workers near the accident site non-productive due to time spent watching or talking?

(a) No ___
(b) Yes ___ , the number of non-productive hours were ____________ at an average hourly rate of $____________

(19) Was any productive time lost because of damage to equipment, property or work in progress?

(a) No ___
(b) Yes ___ , the number of hours lost were ______________ at an average hourly cost of $ ____________

(20) Was any additional work required as a result of the accident?

(a) No ___
(b) Yes ___ , the number of hours to perform this additional work was ___________ hours at an average cost of $____________/hour

(21) Was another worker hired to replace the injured worker?

(a) No ___ (Go to question # 23)
(b) Yes___ , go to # 22.

(22) (a) This worker's productivity was ________% of the injured worker's, prior to the injury.
(b) This individual worked __________ hours at this level, and
(c) The replacement's hourly wage was $____________/ hour.

(23) Was the crew productivity decreased because of the worker's injury?

(a) No ___ (Go to # 25)
(b) Yes ___ (Go to # 24)

(24) (a) Crew productivity in relation to what it had been __________%
(b) Approximate number of hours that productivity was at this level ___________ hours
(c) Average hourly cost of crew $____________/hour

COST OF SUPERVISORY/STAFF EFFORT

(25) Time spent assisting the injured worker _________ hours at average of $__________/hour

(26) Time spent investigating the accident __________ hours at average of $__________/hour

(27) Time spent preparing accident/injury reports (insurance, OSHA, etc.) __________ hours at average of $__________/hour

(28) Time spent in obtaining and training a replacement worker (if injured worker was certified include time for certifying replacement worker) ____________ hours at average of $________/hour

(29) Time spent handling, planning and replacing damaged materials, equipment or work caused by the injured's accident _________ hours at an average of $ __________/hour

(30) Time spent with project owner or news media _________ hours at an average of $__________/hour

(31) Time spent with regulatory inspector as a result of accident __________ hours at an average cost of $__________/hour

OTHER PROJECT COSTS

(32) If a regulatory inspector was on site as a result of this injury, did the inspection adversely impact the productivity of any workcrews?

(a) No _____ (go to #34)
(b) Yes _____ (go to # 33)

(33) It is estimated that the inspection resulted in __________ hours of lost productivity at an average cost of $__________/hour

PROJECT INFORMATION

(34) Value of your contract $_______________ million

(35) Total value of entire project $_______________million

(36) Nature of contract (please check one)

(a) Lump sum or unit price __________
(b) Cost reimburseable __________
(c) Other, please specify ______________________________

(37) Type of project labor: (please check one)

(a) Open or merit shop _____
(b) Union shop ________

(38) Number of employees on project:

(a) Employeed by your company ______________
(b) Estimated total number of all employees on the job site ______________

(39) Type of project:(please check one)

(a) Grassroots construction ____
(b) New construction for an operating plant/facility _____
(c) Maintenance contract work for existing plant or facility _______
(d) Other, please specify ______________________________

(40) How many contractor/employers are there on this project? Include your own company in this total _______________ contractors

INSURANCE COSTS

Please submit the following information based upon the insurance carrier's best estimates This information should be submitted 30 days after the accident.

(41) Worker's Compensation

(a) Medical costs $ ______________

(b) Indemnity costs $ ______________

(c) Other expenses $ ______________

(42) General Liability (Property/Equipment) $ ______________

OTHER COSTS

Other costs associated with this accident which have not been identified in this survey form. (Please identify these cost items ;

(43) Item ______________ $ ______

(44) Item ______________ $ ______

(45) Item ______________ $ ______

This survey instrument was prepared by: ______________

Position: ______________

Telephone Number: ______________

(46) Employer Code: ______________

(Standard Industrial Classification Code 4-digit)

APPENDIX B

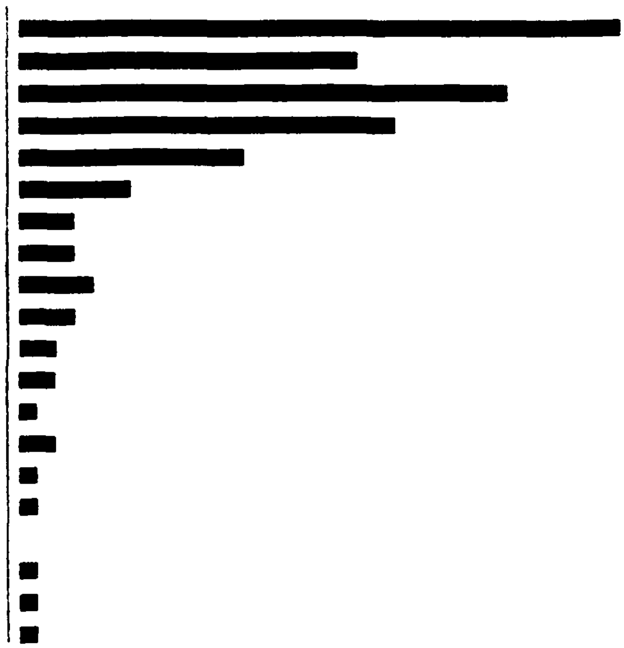
Histograms of Indirect Costs by Incident Type

The following histograms show the data distribution of the indirect costs for Medical Case Injuries and Lost Time Injuries.

MEDICAL CASE INJURIES

INDCOST

Count	Midpoint
129	125.00
71	175.00
104	225.00
78	275.00
46	325.00
25	375.00
12	425.00
12	475.00
14	525.00
11	575.00
9	625.00
7	675.00
2	725.00
9	775.00
4	825.00
3	875.00
1	925.00
3	975.00
5	1025.00
3	1075.00



LOST TIME INJURIES

INDCOST

Count	Midpoint
73	225.00
37	475.00
31	725.00
15	975.00
13	1225.00
5	1475.00
8	1725.00
6	1975.00
10	2225.00
3	2475.00
5	2725.00
3	2975.00
3	3225.00
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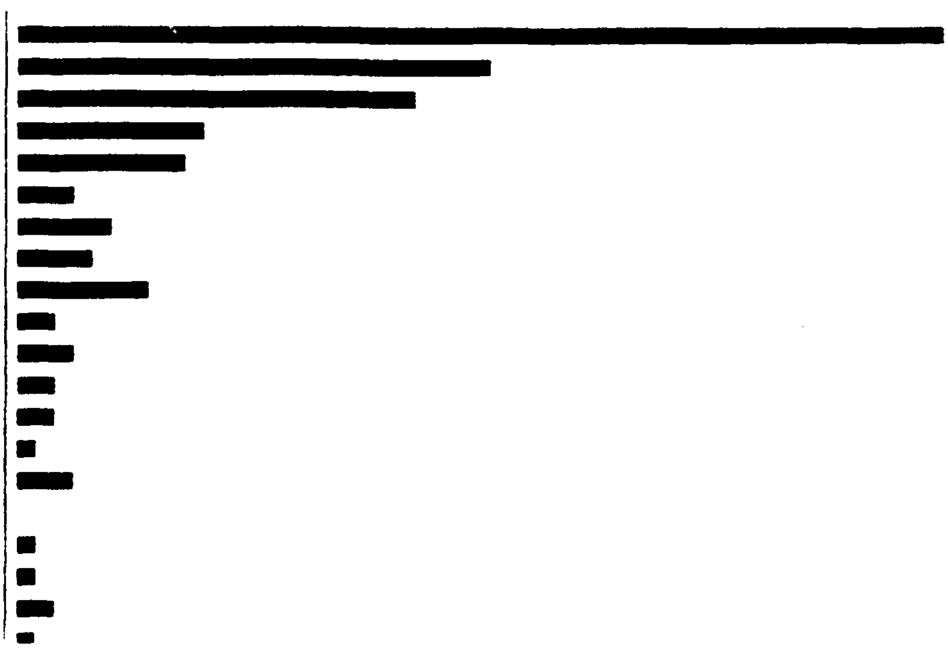


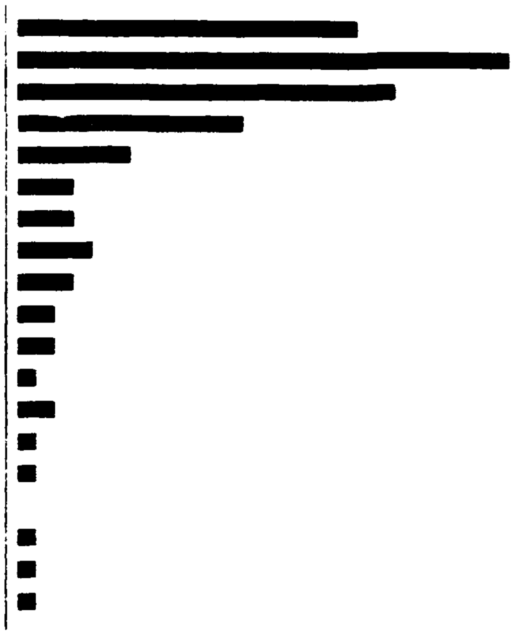
The histograms on the previous page are show that the data are not normally distributed, i.e., a large number of low cost injuries exist in the data along with a relatively few very high cost injuries. This might indicate that the use of mean or average values might not be appropriate. However, a close review of the minimum indirect costs lead this researcher to conclude that for both Medical Case and Lost Time Injuries, some of the data might be underestimating the costs associated with the injuries.

Since the indirect costs were all determined to have a $100 material damage cost, the absolute minimum indirect cost, as calculated by this study, was $100. For the Medical Case Histogram, 129 injury cases reported total indirect costs between the minimum $100 and $150 (midpoint of $125). A total indirect cost of $150 means only $50 worth of productivity was lost due to the injury itself, including lost productivity of the injured worker, and the affect on the worker's crew. This researcher considered this reported cost of $50 as being unreasonably low. Another histogram was developed excluding cases where the total indirect cost was below $150. This is shown on the following page. The results indicate a slightly more normally shaped distribution. This distribution provides some insight as to why previous studies with small sample size had not lent themselves well to rigorous statistical analysis. With the large sample size utilized in this research, the fact that the data were not normally distributed did not compromise the study results.

MEDICAL CASE INJURIES (INDIRECT COST OVER $150)

INDCOST

Count	Midpoint
71	175.00
104	225.00
78	275.00
46	325.00
25	375.00
12	425.00
12	475.00
14	525.00
11	575.00
9	625.00
7	675.00
2	725.00
9	775.00
4	825.00
3	875.00
1	925.00
3	975.00
5	1025.00
3	1075.00
0	1125.00



For the Lost Time Histogram, 73 cases reported total indirect costs between $100 and $350. These data do not appear to be normally distributed either. A second histogram is shown below for the injury cases where the indirect cost exceed $150. This does not significantly change the shape of the distribution curve. However, it was not surprising that the distribution is not normal, since there were some Lost Time Injuries that have very high total indirect costs, several in this study exceeded $10,000. It was determined that using average or mean results was still appropriate in order to accurately present the potential cost of injuries. Thus, it is reasonable to assume that while most injuries may cost a small amount, eventually a high cost injury will be incurred that will significantly increase the mean or average cost of the injuries.

LOST TIME INJURIES (INDIRECT COST OVER $150)

INDCOST

Count	Midpoint
69	275.00
31	525.00
31	775.00
11	1025.00
12	1275.00
9	1525.00
4	1775.00
8	2025.00
10	2275.00
3	2525.00
3	2775.00
3	3025.00
3	3275.00
2	3525.00
4	3775.00
0	4025.00
2	4275.00
3	4525.00
1	4775.00
1	5025.00

APPENDIX C

SPSS Definition File

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 OTHRLOST 17-19 PRDCTITY 21-23 HRSATLVL 25-27
/ASSISHRS  1- 3 ASSISWGE  5- 8 XPRTCOST 10-13 IDLEWRKR 15    IDLEHOUR 17-19
 IDLEWAGE 21-24 ACDAMAGE 26    DMAGEHRS 28-30 DMAGEWGE 32-35 ADEDWORK 37
 ADWRKHRS 39-41 ADWRKWGE 43-46 NEWWORKR 48    NEWPRDTY 50-52 NEWHOURS 54-56
 NEWWAGES 58-61 PRDTYDEC 63    PRDTYLVL 65-67 PRDTYHRS 69-71 CREWCOST 73-76
/ASISHRS2  1- 3 ASISCOST  5- 8 INVESHRS 10-12 INVESWGE 14-17 REPTHOUR 19-21
 REPTCOST 23-26 TRAINHRS 28-30 TRANCOST 32-35 PLANGHRS 37-39 PLANCOST 41-44
 MEDIAHRS 46-48 MEDIACST 50-53 REGUHOUR 55-57 REGUCOST 59-62 INSPECTR 64
 INSPCTHR 66-68 INSPCOST 70-73
/CNTCTVAL  1- 4 PRFCTVAL  6- 9 CNTCTTYP 11    SHOPTYPE 13    WRKRQUAN 15-18
 TOTLWRKR 20-23 PRJCTTYP 25    CNTRTRNO 27-29 MEDCOSTS 31-35 INDEMCST 37-41
 OTHERCST 43-47 GENLLIAB 49-53 MISCCOST 55-59
/WHOPREPD 80
/DUMMYVAR 80.

variable labels
/RESPNDNT "Respondant Number"
/GENLINFO "Company Name, et. al."
/MOREINFO "Name of Injured, Date Occured"
/CRAFTNUM "Craft/Occupation"
/INCIDENT "Nature of Incident"
/JOBRELAT "Job Relatedness of Injury"
/WRKRWAGE "Worker's Hourly Wage"
/HOURLOST "Productive Time Lost on Day of Injury"
/OTHRLOST "Productive Time Lost Subsequently"
/PRDCTITY "Productivity Level After Injury"
/HRSATLVL "Hours Worked at Reduced Level"
/ASSISHRS "Time Spent Assisting Injured"
/ASSISWGE "Avg. Hourly Wages of Those Assisting"
/XPRTCOST "Cost of Transporting the Injured"
/IDLEWRKR "Were Others Watching?"
/IDLEHOUR "Time Lost By Those Watching"
/IDLEWAGE "Wages of Those Watching"
/ACDAMAGE "Property Damage Occure?"
/DMAGEHRS "Time Spent Repairing Damage"
/DMAGEWGE "Wages of Those Repairing"
/ADEDWORK "Accident Create Added Work?"
/ADWRKHRS "Time Req'd to Complete Added Work"
/ADWRKWGE "Wages of Those Doing Added Work"
/NEWWORKR "Replacement Hired?"
/NEWPRDTY "Replacement's Relative Productivity"
/NEWHOURS "Hours Worked by Replacement"
/NEWWAGES "Wage of Replacement"
/PRDTYDEC "Accident Reduced Crew Productivity?"
/PRDTYLVL "Crew Productivity After Accident"
/PRDTYHRS "Hours Spent at Reduced Level"
/CREWCOST "Hourly Cost of Running Crew"
/ASISHRS2 "Staff Time Assisting Injured"
/ASISCOST "Salary of Assisting Staff Members"
/INVESHRS "Time Spent Investigating Incident"
/INVESWGE "Salaries of Those Investigation"
/REPTHOUR "Time Spent Writing Reports"
/REPTCOST "Salaries of Those Writing Report"
/TRAINHRS "Time Spent Training Replacement"
/TRANCOST "Wage of Trainer"
/PLANGHRS "Time Planning/Handling Damages"
/PLANCOST "Salaries of Those Involved"
/MEDIAHRS "Time with Media/Project Owner"
/MEDIACST "Salaries of Those with Media/Owner"
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/REGUHOUR "Time with Regulatory Inspector"
/REGUCOST "Salaries of Those Involved"
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/INSPCTHR "Time Lost Due to Inspection"
/INSPCOST "Hourly Cost of Lost Time"
/CNTCTVAL "Value of Contract"
/PRFCTVAL "Value of Project"
/CNTCTTYP "Contract Type"
/SHOPTYPE "Shop Type"
/WRKRQUAN "Number of Workers Employed"
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/PRJCTTYP "Type of Project"
/CNTRTRNO "Number of Contractors on Project"
/MEDCOSTS "Medical Costs"
/INDEMCST "Indemnity Costs"
/OTHERCST "Other Expenses"
/GENLLIAB "General Liability"
/MISCCOST "Other Associated Costs"
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/DUMMYVAR "Data Spacer".

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value labels
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 4 "Carpet Installer" 5 "Cement Finisher" 6 "Crane Operator"
 7 "Electrical Powerman" 8 "Electrician"
 9 "Excavater Loader Ops." 10 "Grader Dozer Ops."
 11 "Insulation Worker" 12 "Laborer" 13 "Mechanic Repairer" 14 "Painter"
 15 "Plasterer" 16 "Plumber Pipefitter" 17 "Roofer Slater"
 18 "Sheetmetal" 19 "Structural Metal" 20 "Supervisor Foreman"
 21 "Truck Driver" 22 "Welder" 23 "Other"
/INCIDENT 1 "Medical Case" 2 "Lt. Duty/Lost Workday"
/JOBRELAT 1 "Work Related, Ver." 2 "Work Related, Claim"
          3 "Unrelated, Compensable"
/IDLEWRKR 1 "Workers Watched" 2 "Workers Didn't Watch"
/ACDAMAGE 1 "Prop. Eqpt. Work Damaged"
          2 "Prop. Eqpt. Work Undamaged"
/ADEDWORK 1 "Added Work Created"
          2 "No Added Work Created"
/NEWWORKR 1 "Replacement Hired" 2 "No Replacement Hired"
/PRDTYDEC 1 "Crew Less Productive" 2 "Crew Unaffected"
/INSPECTR 1 "Inspector Affected Productivity" 2 "Productivity Uninfluenced"
/CNTCTTYP 1 "Lump Sum/Unit Price" 2 "Cost Reimburseable" 3 "Other"
/SHOPTYPE 1 "Open or Merit Shop" 2 "Union Shop"
/PRJCTTYP 1 "Grassroots Construction" 2 "Construction, Existing Fac."
          3 "Maintenance Contract" 4 "Other".

RECODE WRKRWAGE TO INSPCOST (9 = 0).
if (RESPNDNT ge 0) BENEFITS = 1.30.
RECODE CNTCTVAL TO MISCCOST (9 = 0).
IF (RESPNDNT EQ 514) HOURLOST = 8.0

compute WRKRWAGE = WRKRWAGE * BENEFITS.
compute ASSISWGE = ASSISWGE * BENEFITS.
compute IDLEWAGE = IDLEWAGE * BENEFITS.
compute DMAGEWGE = DMAGEWGE * BENEFITS.
compute ADWRKWGE = ADWRKWGE * BENEFITS.
compute NEWWAGES = NEWWAGES * BENEFITS.
compute CREWCOST = CREWCOST * BENEFITS.

compute LOSTHRS= HOURLOST + OTHRLOST + (100-PRDCTITY) * HRSATLVL.
```

```
compute INJURED= WRKRWAGE * HOURLOST * .01.
compute FOLLOWP= WRKRWAGE * OTHRLOST * .01.
compute LOSTPRD= WRKRWAGE * (100 - PRDCTITY) * HRSATLVL * .0001.
compute WORKER=  INJURED + FOLLOWP + LOSTPRD.

compute CREWHRS= ASSISHRS + IDLEHOUR + (100-PRDTYLVL) * PRDTYHRS.

compute FELLOWK= ASSISHRS * ASSISWGE * .01.
compute TRANSPT= XPRTCOST.
compute WATCHNG= IDLEHOUR * IDLEWAGE * .01.
compute CREWPRD= (100 - PRDTYLVL) * PRDTYHRS * CREWCOST * .0001.
compute LOSTCREW= FELLOWK + WATCHNG + CREWPRD.

compute CREWLS=  FELLOWK + TRANSPT + WATCHNG.
compute DAMAGED= DMAGEHRS * DMAGEWGE * .01.
compute NEWMATL= PLANGHRS * PLANCOST * .01.
compute MATLCS=  DAMAGED + NEWMATL.
compute MOREWRK= ADWRKHRS * ADWRKWGE * .01.
compute REHIRED= (100 - NEWPRDTY) * NEWHOURS * NEWWAGES * .0001.
compute CREWMN=  MOREWRK + REHIRED + CREWPRD.
compute SUPTHLP= ASISHRS2 * ASISCOST * .01.
if (INCIDENT eq 1 AND SUPTHLP gt 2000) SUPTHLP = 2000.
compute INVESTG= INVESHRS * INVESWGE * .01.
if (INCIDENT eq 1 AND INVESTG gt 5000) INVESTG = 5000.
compute REPORTS= REPTHOUR * REPTCOST * .01.
compute RETRAIN= TRAINHRS * TRANCOST * .01.
compute SUPVSR=  SUPTHLP + INVESTG + REPORTS + RETRAIN.
compute NEWSMEN= MEDIAHRS * MEDIACST * .01.
compute REGCREW= REGUHOUR * REGUCOST * .01.
compute INSPECT= INSPCTHR * INSPCOST * .01.
compute INSPTV=  NEWSMEN + INSPECT + REGCREW.
compute INDIRECT= WORKER + CREWLS + MATLCS + CREWMN + SUPVSR + INSPTV.
compute DIRECT=   MEDCOSTS + OTHERCST + MISCCOST + INDEMCST + GENLLIAB.
compute FACTOR=  INDIRECT / DIRECT.

if (INCIDENT eq 1) CLAIMS = 0.60 * INDIRECT.
if (INCIDENT eq 2) CLAIMS = 10.0 * INDIRECT.

compute MATERIAL = 100.
compute IMPACT = .20 * INDIRECT.
compute NEWFACTR = (INDIRECT + MATERIAL + CLAIMS + IMPACT)/ DIRECT.
COMPUTE INDCOST= INDIRECT + IMPACT + MATERIAL.
compute IMPFACTR = (INDIRECT + MATERIAL + IMPACT)/DIRECT.
COMPUTE IND$MED1= 150 + (80 * (ASISHRS2 + HOURLOST)).
COMPUTE IND$MEDF= 150 + (15 * OTHRLOST) + (30 * HOURLOST) + (100 * ASISHRS2).
COMPUTE IND$LT1 = 625 +(105 * (INVESHRS + HOURLOST)).
COMPUTE IND$LTF = 625 + (50 * INVESHRS) + (20 * (HOURLOST + OTHRLOST)).


compute MATFACTR = (INDIRECT + MATERIAL)/DIRECT.
if (HOURLOST eq 0) HOURGRP = 0.
if (HOURLOST gt 0 and HOURLOST le 2) HOURGRP = 1.
if (HOURLOST gt 2 and HOURLOST le 3) HOURGRP = 2.
if (HOURLOST gt 3 and HOURLOST le 4) HOURGRP = 3.
if (HOURLOST gt 4 and HOURLOST le 5) HOURGRP = 4.
if (HOURLOST gt 5 and HOURLOST le 6) HOURGRP = 5.
if (HOURLOST gt 6) HOURGRP = 6.

if (CREWCOST eq 0) CREWGRP = 0.
if (CREWCOST gt 0 and CREWCOST le 1000) CREWGRP = 1.
if (CREWCOST gt 1000 and CREWCOST le 2000) CREWGRP = 2.
if (CREWCOST gt 2000 and CREWCOST le 3000) CREWGRP = 3.
if (CREWCOST gt 3000 and CREWCOST le 4000) CREWGRP = 4.
if (CREWCOST gt 4000 and CREWCOST le 5000) CREWGRP = 5.
```

```
if (CREWCOST gt 5000) CREWGRP = 6.

if (PRDCTITY eq 0) PRDCGRP = 0.
if (PRDCTITY gt 0 and PRDCTITY le 25) PRDCGRP = 1.
if (PRDCTITY gt 25 and PRDCTITY le 50) PRDCGRP = 2.
if (PRDCTITY gt 50 and PRDCTITY le 75) PRDCGRP = 3.
if (PRDCTITY gt 75 and PRDCTITY lt 100) PRDCGRP = 4.
if (PRDCTITY eq 100) PRDCGRP = 5.

if (DIRECT ge 0 and DIRECT lt 50) DIRGRP = 1.
if (DIRECT ge 50 and DIRECT lt 100) DIRGRP = 2.
if (DIRECT ge 100 and DIRECT lt 150) DIRGRP = 3.
if (DIRECT ge 150 and DIRECT lt 200) DIRGRP = 4.
if (DIRECT ge 200 and DIRECT lt 300) DIRGRP = 5.
if (DIRECT ge 300 and DIRECT lt 400) DIRGRP = 6.
if (DIRECT ge 400 and DIRECT lt 1000) DIRGRP = 7.
if (DIRECT ge 1000 and DIRECT lt 2000) DIRGRP = 8.
if (DIRECT ge 2000 and DIRECT lt 5000) DIRGRP = 9.
if (DIRECT ge 5000 and DIRECT lt 10000) DIRGRP = 10.
if (DIRECT gt 10000) DIRGRP = 11.

IF (DIRGRP EQ 1) CAT = 1.
IF (DIRGRP EQ 2) CAT = 2.
IF (DIRGRP EQ 3) CAT = 3.
IF (DIRGRP EQ 4) CAT = 4.
IF (DIRGRP EQ 5) CAT = 5.
IF (DIRGRP EQ 6 OR DIRGRP EQ 7) CAT = 6.
IF (DIRGRP GE 8) CAT = 7.

compute CNTCTVAL = CNTCTVAL * 1000.
compute PRFCTVAL = PRFCTVAL * 1000.

if (CNTCTVAL gt 0 and CNTCTVAL le 2000) CNTCGRP = 1.
if (CNTCTVAL gt 2000 and CNTCTVAL le 10000) CNTCGRP = 2.
if (CNTCTVAL gt 10000 and CNTCTVAL le 75000) CNTCGRP = 3.
if (CNTCTVAL gt 75000) CNTCGRP = 4.

if (PRFCTVAL gt 0 and PRFCTVAL le 15000) PRFCGRP = 1.
if (PRFCTVAL gt 15000 and PRFCTVAL le 70000) PRFCGRP = 2.
if (PRFCTVAL gt 70000 and PRFCTVAL le 140000) PRFCGRP = 3.
if (PRFCTVAL gt 140000) PRFCGRP = 4.

if (WRKRQUAN gt 0 and WRKRQUAN le 25) WRKRGRP = 1.
if (WRKRQUAN gt 25 and WRKRQUAN le 100) WRKRGRP = 2.
if (WRKRQUAN gt 100 and WRKRQUAN le 400) WRKRGRP = 3.
if (WRKRQUAN gt 400) WRKRGRP = 4.

if (TOTLWRKR gt 0 and TOTLWRKR le 50) TOTLGRP = 1.
if (TOTLWRKR gt 50 and TOTLWRKR le 250) TOTLGRP = 2.
if (TOTLWRKR gt 250 and TOTLWRKR le 500) TOTLGRP = 3.
if (TOTLWRKR gt 500) TOTLGRP = 4.

if (CNTRTRNO gt 0 and CNTRTRNO le 4) CNTRGRP = 1.
if (CNTRTRNO gt 4 and CNTRTRNO le 8) CNTRGRP = 2.
if (CNTRTRNO gt 8 and CNTRTRNO le 20) CNTRGRP = 3.
if (CNTRTRNO gt 20 and CNTRTRNO lt 100) CNTRGRP = 4.
if (CNTRTRNO ge 100) CNTRGRP = 5.

variable labels
/CNTRGRP "Number of Contractors on Project"
/TOTLGRP "Total Number of Workers on Project"
/WRKRGRP "Number of Workers Employed"
/CNTCGRP "Value of the Contract"
/PRFCGRP "Value of the Project"
```

```
recode DIRECT (0 = 9).

if (NEWWORKR eq 1) NEWWAGES= 0.
if (PRDTYDEC eq 1) CREWCOST= 0.
if (INSPECTR eq 1) INSPCOST= 0.

compute fact10 = factor.
compute newfactn = newfactr.
if (fact10 lt .055 or fact10 ge 3.753) fact10 = 9.
if (newfactn lt .475 or newfactn ge 23.042) newfactn = 9.
missing values
/fact10, newfactn, DIRECT, INDIRECT, FACTOR, MATFACTR, IMPFACTR (9).
COMPUTE DIRECTEN = DIRECT.
IF (SHOPTYPE EQ 1 AND DIRECT GT 1122) DIRECTEN = 9.
IF (SHOPTYPE EQ 2 AND DIRECT GT 5930) DIRECTEN = 9.
COMPUTE INDIRTEN = INDIRECT.
IF (SHOPTYPE EQ 1 AND INDIRECT GT 1183) INDIRTEN = 9.
IF (SHOPTYPE EQ 2 AND INDIRECT GT 2120) INDIRTEN = 9.
MISSING VALUES
/DIRECTEN, INDIRTEN (9).
IF (PRJCTTYP EQ 0) PRJCTTYP = 9.
IF (CNTCTTYP EQ 0) CNTCTTYP = 9.
IF (SHOPTYPE EQ 0) SHOPTYPE = 9.
COMPUTE JOBVALUE = 100 * CNTCTVAL.
```

APPENDIX D

COMPARING ESTIMATING MODELS FOR UNION AND OPEN SHOP EMPLOYERS

The following table shows the regression analysis results for analyzing the effectiveness of the cost model for both the open and union shop employers. The General Case model results were from the model developed from all the data. The specific models for open and union shop employers are shown on the following page in this appendix.

	R Squared Values		
	General Case Model	Open Shop Model	Union Shop Model
Medical Cases:			
Quick Model			
All Employers	37%		
Open Shop	69%	74%	
Union Shop	32%		29%
Follow-Up Model			
All Employers	79%		
Open Shop	79%	84%	
Union Shop	55%		62%
Lost Time Cases:			
Quick Model			
All Employers	42%		
Open Shop	59%	59%	
Union Shop	12%		11%
Follow-Up Model			
All Employers	81%		
Open Shop	76%	68%	
Union Shop	92%		96%

SPECIFIC MODELS FOR UNION AND OPEN SHOP EMPLOYERS

OPEN SHOP EMPLOYERS

<u>Medical Case:</u>

Quick: $124 + $19(A x Awage) + $3.4(H x Hwage)

Follow-Up $81 + $10.8(A x Awage) + $2.3(H x Hwage) + $1.3(F x Hwage)

<u>Lost Time Case:</u>

Quick: $1262 + $4.2(I x Iwage) + $1.2(H x Hwage)

Follow-Up $900 + $4.2(I x Iwage) + $1.2(H x Hwage) + $1.1(F x Hwage)

UNION SHOP EMPLOYERS

<u>Medical Case:</u>

Quick: $339 + $8(A x Awage) + $1.3(H x Hwage)

Follow-Up $255 + $7.1(A x Awage) + $1.1(H x Hwage) + $1.8(F x Hwage)

<u>Lost Time Case:</u>

Quick: $1502 + $4.8(I x Iwage) + $1.3(H x Hwage)

Follow-Up $386 + $2.2(I x Iwage) + $1.0(H x Hwage) + $1.1(F x Hwage)

Note: The H,A,I and F variables are the same as in the General Models, the Hwage, Awage and Iwage are the average hourly wages (in $) for the worker(H),staff (A) and investigator (I), respectively.

APPENDIX E

COMPARING ESTIMATING MODELS FOR LUMP SUM AND COST PLUS CONTRACTS

The following table shows the regression analysis results for analyzing the effectiveness of the cost model for use with lump sum and cost plus type contracts. The CII study also had a category of "Other" for contract type. This contract type was not specifically analyzed. The General Case model results were from the model developed from all three types of contracts. The specific models for lump sum and cost plus contracts are shown on the following page in this appendix.

	R Squared Values		
	General Case Model	Lump Sum Model	Cost Plus Model
Medical Cases:			
Quick Model			
All Contract Types	37%		
Lump Sum	63%	74%	
Cost Plus	55%		57%
Follow-Up Model			
All Contract Types	79%		
Lump Sum	75%	81%	
Cost Plus	63%		70%
Lost Time Cases:			
Quick Model			
All Contract Types	42%		
Lump Sum	67%	69%	
Cost Plus	4%		5%
Follow-Up Model			
All Contract Types	81%		
Lump Sum	84%	84%	
Cost Plus	69%		70%

SPECIFIC MODELS FOR LUMP SUM AND COST PLUS CONTRACTS

LUMP SUM CONTRACTS

Medical Case:

Quick:	\$163 + \$34H + \$176A
Follow-Up	\$133 + \$30H + \$153A + \$9F

Lost Time Case:

Quick:	\$915 - \$2H + \$64I
Follow-Up	\$446 + \$5H + \$53I + \$23F

COST PLUS CONTRACTS

Medical Case:

Quick:	\$300 + \$34H + 78A
Follow-Up	\$195 + \$27H + \$66A + \$39F

Lost Time Case:

Quick:	\$1705 + \$20H + \$67I
Follow-Up	\$882 + \$20H + \$79I +\$18F

Note: The H, A, I and F variables represent the same hourly averages as for the General Models.

APPENDIX F

Development of Cost Models

As presented in Part B of this study, the models were developed from the results of regression analysis. The various indirect cost categories and their cost components were analyzed for their effect on total indirect costs for both Medical Case Injuries and Lost Time Injuries. The goal of developing reasonably accurate yet simple models required optimizing the number of variables in the equation. The following graphs show the relationships between the R Squared value from the regression analysis and the number of variables in the model for each type of injury.

For both types of injuries, it was decided to use a two variable equation for the Quick model and a three variable equation for the Follow-Up model to achieve the best balance between accuracy and simplicity.